

Inertial Fusion Technology Spin-Offs - History Provides a Glimpse of the Future

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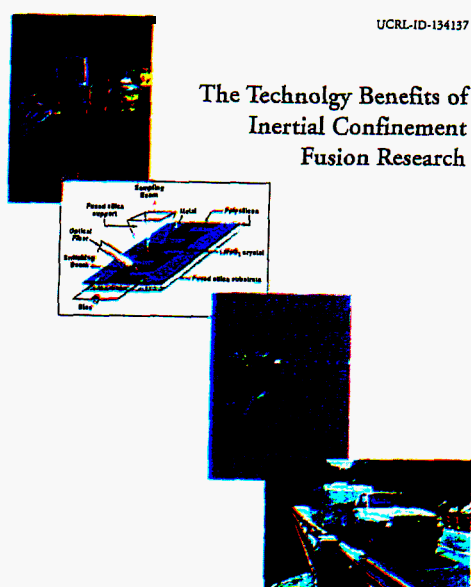
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The development and demonstration of inertial fusion is incredibly challenging because it requires simultaneously controlling and precisely measuring parameters at extreme values in energy, space, and time. The challenges range from building megajoule (10^6 J) drivers that perform with percent-level precision to fabricating targets with submicron specifications to measuring target performance at micron scale (10^{-6} m) with picosecond (10^{-12} s) time resolution. Over the past 30 years in attempting to meet this challenge, the inertial fusion community around the world has invented new technologies in lasers, particle beams, pulse power drivers, diagnostics, target fabrication, and other areas. These technologies have found applications in diverse fields of industry and science. Moreover, simply assembling the teams with the background, experience, and personal drive to meet the challenging requirements of inertial fusion has led to spin-offs in unexpected directions, for example, in laser isotope separation, extreme ultraviolet (EUV) lithography for microelectronics, compact and inexpensive radars, advanced laser materials processing, and medical technology. It is noteworthy that more than 40 R&D 100 awards, the “Oscars of applied research” have been received by members of the inertial fusion community over this period. Not surprisingly, the inertial fusion community has created many new companies based on these advances. The experience of inertial fusion research and development of spinning off technologies has not been unique to any one laboratory or country but has been similar in main research centers in the United States, Europe, and Japan.

The capabilities of inertial fusion research have also been exploited in numerous and diverse specific lines of scientific research. Examples include laboratory simulation of astrophysical phenomena; studies of the equation of state (EOS) of matter under conditions relevant to the interior of planets and stars; development of uniquely intense sources of extreme ultraviolet (EUV) to hard x-ray emission, notably the x-ray laser; understanding of the physics of strong field interaction of light and matter; and related new phenomena such as laser-induced nuclear processes and high-field-electron accelerators. Some of these developments have potential themselves for further scientific exploitation such as the scientific use of advanced light sources. There are also avenues for commercial exploitation, for example the use of laser plasma sources in EUV lithography.

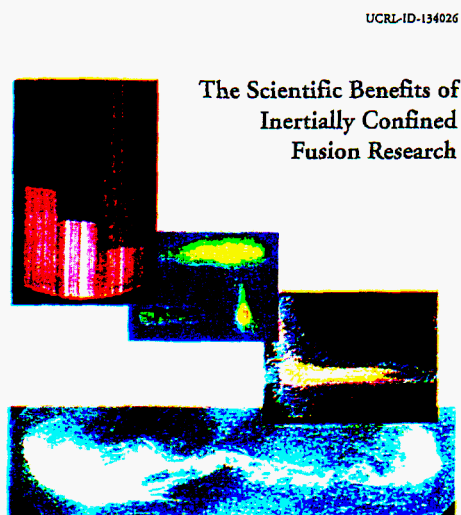
Strengthening and broadening the inertial fusion effort to focus on creating a new source of electrical power (inertial fusion energy [IFE]) that is economically competitive and environmentally benign will yield rich rewards in technology spin-offs. The additional challenges presented by IFE are to make drivers affordable, efficient, and long-lived while operating at a repetition rate of a few Hertz; to make fusion targets that perform consistently at high-fusion yield; and to create target chambers that can repetitively handle greater than 100-MJ yields while producing minimal radioactive by-products. Meeting these challenges will produce spin-off value of enormous magnitude.

Further discussion of the spin-off of the inertial fusion program is provided in two documents written for the Secretary's Energy Advisory Board 1999 review of magnetic and inertial fusion research. To obtain these documents either in hard copy or electric format, please contact Howard Powell at Lawrence Livermore National Laboratory (powell4@llnl.gov or 925-422-6149).



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Figure 1 (from top to bottom)
The ICF Program has a long history of providing spin-offs to the semiconductor industry. The prototype system shown here will be used in extreme ultraviolet lithography development for the manufacture of semiconductor circuits; electro-optic sampling circuit used to measure subpicosecond electrical pulses; short-pulse laser removal of dental caries; and High-Speed Electromagnetic Roadway Mapping and Evaluation System using micropower impulse radar in a drive-over bridge inspection test.



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Figure 2 (from top to bottom)
Top-Data recorded by a velocity interferometer for any reflector (VISAR) in an equation of state (EOS) experiment at the University of Rochester's OMEGA laser facility.
Center-Use of a laser-generated x-ray source to make a streak camera time-resolved diffraction measurement showing a change in direction of Bragg-reflected x-rays when an Si crystal lattice is compressed by a laser-driven shock wave. The data is from the Trident laser facility at the Los Alamos National Laboratory.
Bottom-An astrophysical Herbig-Haro supersonic radiation-cooled jet and (inset) a laboratory analog created at the Lawrence Livermore National Laboratory Nova laser.